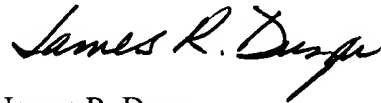


REMARKS

No new matter has been added. The Applicant again requests entry of the amendments as set forth in the Appendices hereto prior to examination of the application on the merits.

Respectfully submitted,



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JRD/df/dp

Enclosure: Version with Markings Showing Changes Made

VERSION WITH MARKINGS SHOWING CHANGES MADE

IN THE SPECIFICATION

[0003] Consumers want their portable devices to perform the same functions as their desktop computers, therefore requiring large amounts of memory in a much smaller electronic device. One way of accomplishing this is to increase the density of a semiconductor die package by using the package's real estate more efficiently. One advantage of high density packaging is that it decreases the length of the connections between the semiconductor die and the package, allowing the semiconductor die to respond faster. Also, reducing the length of the connections reduces the signal propagation time and makes the signal paths less vulnerable to the [effects] affects of noise.

[0005] A multichip module comprised of stacked semiconductor [die] dice is disclosed in United States Patent 5,323,060, issued to Fogal et al. The semiconductor [die] dice are electrically connected to a substrate by extending long bond wires from bond pads on each semiconductor die to the substrate. In order to accommodate the loop height of the bond wires, a thick adhesive layer is applied between the semiconductor [die] dice. The adhesive layer must be thick enough that the bond wires of the lower semiconductor die do not contact the upper semiconductor die. This multichip module is not suited for small electronic devices because the adhesive layer between the [die] dice increases the overall thickness of the semiconductor package.

[0008] In United States Patent 5,994,166 issued to Akram et al. a dense semiconductor package comprising multiple substrates with attached [flip chips] flip-chips is disclosed. The substrates are stacked on top of one another. Column-like connections positioned between the stacked substrates provide electrical communication. The electrical connections must be of sufficient height to provide enough clearance between substrates to mount components and also

must be of sufficient strength to provide support between the substrates. Since the column-like connections cause unused space between the substrates, this semiconductor package is incompatible with electronic devices that require small semiconductor packages.

[0009] While numerous high density semiconductor packages exist, they share a common disadvantage in that they inefficiently use the space of the semiconductor package. The unused or wasted space may be the result of thick adhesive layers between semiconductor [die] dice or may be caused by rigid interposers or other spacers. Small electronic devices, such as cell phones and PDAs, have very limited space and [can not] cannot afford to waste any of this space. Reducing the wasted or unused space in a semiconductor die package is essential because large packages occupy too much of this limited space. It would be preferable to reduce the unused or wasted space in a stack of semiconductor [die] dice by more closely spacing the semiconductor [die] dice. It would be more preferable for the semiconductor [die] dice to be spaced substantially one on top of another. It would be most preferable for the overall size of a high density semiconductor package to be caused only by the thickness of the semiconductor die and a substrate, without substantial thickness coming from additional packaging or unused space.

[0010] Methods for connecting [die] dice to a substrate are well [know] known in the art. For example, wire bonding, tape automated bonding ("TAB"), and controlled collapse chip connection ("C4") are commonly used to physically and electrically connect semiconductor [die] dice to a substrate. Wire bonding utilizes fine wire conductors bonded on one end to the substrate and on the other end to electrical contacts on the semiconductor die. Because wire bonding requires wires to be welded to the die, there must be adequate space to accommodate the wires. TAB utilizes patterned metal on a polymeric tape to join dice together. The joined semiconductor dice are attached to a substrate by outer lead bonding. C4, or [flip chip] flip-chip, bonding uses solder balls on the surface of a semiconductor die to bond the semiconductor die to a substrate.

[0011] In addition to the [above mentioned] above-mentioned methods, the prior art also discloses using vias to attach a semiconductor die to a substrate and to provide electrical communication between the semiconductor die and substrate. The vias may be filled with conductive metal or flexible leads may be run through the vias to provide electrical communication. As mentioned above, United States Patent 5,128,831 issued to Fox, III et al. teaches a high density package composed of multiple submodules, each of which contain a chip bonded to a substrate. Each substrate has a metallization pattern, which comprises multiple conductive traces. A spacer is adhesively bonded to the peripheral upper surface of each submodule before the submodules are stacked. Both the substrate and spacer contain vias that are coincident and substantially coaxial to each other when the package is assembled. The vias are filled with solder to electrically connect the traces of all the submodules. Similarly, United States Patent 5,148,266 issued to Kane et al., mentioned in more detail below, uses solid vias to electrically interconnect two chips on opposite sides of a flexible carrier.

[0014] In United States Patents 5,148,266 and 5,682,061 issued to Khandros et al., a semiconductor chip assembly containing an interposer and flexible leads is disclosed. The interposer separates a semiconductor chip and a substrate. The chip and substrate electrically communicate through flexible leads that run through apertures in the interposer. The leads connect the chip to terminals on the interposer, which are then connected to contact pads on the substrate. The flexible leads allow for movement of the contacts on the chip and, therefore, reduce the stresses caused by thermal cycling.

[0018] While the [above mentioned] above-mentioned inventions disclose flexible components in semiconductor die packages, they only disclose attaching one semiconductor die to a substrate. Since high density semiconductor packages are necessary for new generations of electronic devices, it would be preferable to combine flexible components with semiconductor die packages that can accommodate multiple semiconductor [die] dice.

[0019] United States Patent 5,252,857 issued to Kane et al., discloses both of these features. A dense memory package is disclosed where two memory chips are mounted face-to-face on opposite sides of a flexible carrier or interposer. The two chips contain solder bumps that align when the chips are placed face to face. In addition, the interposer contains pads that are coated with low melting point solder. The bumps on the chips contact the pads on the interposer and are soldered together. Kane also discloses a plurality of pairs of chips mounted on opposite sides of a flexible carrier. The flexible carrier with the attached chips can be folded to connect with substrates, such as printed circuit boards. While Kane discloses a flexible carrier that can be used to connect multiple die to a printed circuit board or backplane, Kane discloses that the pairs of [die] dice are mounted face-to-face on opposite sides of the flexible carrier.

[0020] The present invention solves the [above mentioned] above-mentioned problems. The present invention discloses a high density semiconductor package that has reduced or eliminated the unused space between stacked semiconductor die. The resulting high density semiconductor package of the present invention is small, and is, therefore, useful in portable electronic devices such as cell phones and PDAs.

[0021] The present invention relates to a folded interposer and a high density semiconductor package that utilizes the folded interposer. The folded interposer is comprised of a thin, flexible material that can be folded around one or multiple semiconductor [die] dice. The folded interposer allows multiple semiconductor [die] dice to be efficiently stacked in a high density semiconductor package by reducing the unused or wasted space between stacked semiconductor [die] dice. The present invention also relates to a method of packaging semiconductor [die] dice in a high density arrangement and a method of forming the high density semiconductor die package. Finally, the present invention relates to a computer system that incorporates the folded interposer in a high density semiconductor die package.

[0025] FIG. 3 is a side view of an interposer of the present invention folded around two semiconductor [die] dice;

[0026] FIG. 4 is a side view of an interposer of the present invention folded around two semiconductor [die] dice and attached to a substrate;

[0027] FIG. 5 is a side view of an interposer of the present invention folded in a serpentine fashion around more than two semiconductor [die] dice; and

[0030] [Illustrated] As illustrated in drawing [FIG'S.] FIGS. 2 and 3 [are that] the interposer **10** is flexible enough to fold around one or multiple semiconductor [die] dice **12**. Preferably, the semiconductor [die] dice **12** are bare, unpackaged die. As is illustrated in drawing FIG. 2 (vias not shown), the interposer **10** surrounds at least three sides of one semiconductor die **12**, to form an intermediate packaging structure **28**. Illustrated in drawing FIG. 3 (vias not shown) is an intermediate packaging structure **28** containing multiple semiconductor [die] dice **12**, wherein the interposer **10** surrounds at least two sides of each semiconductor die.

[0031] Methods of attaching a semiconductor die to a substrate are well known in the art. Any means known in the art for attaching the semiconductor die to the interposer may be used in the present invention. Intermediate packaging structure **28**, which includes the interposer **10** and attached semiconductor die **12**, is attached to a substrate to form a high density semiconductor package **14** (see FIG. 4).

[0032] The present invention also relates to a high density semiconductor die package **14** utilizing the folded interposer **10**. As is best illustrated in drawing [FIG'S.] FIGS. 4 through 6, the folded interposer **10** is used to attach one or multiple semiconductor [die] dice **12** to a substrate **22**, thus forming the high density semiconductor package **14**. The interposer **10**,

which has two surfaces, is folded around the semiconductor die 12 to form intermediate packaging structure 28. As is best illustrated in drawing FIG. 2 (vias not shown), the interposer 10 surrounds at least three sides of one semiconductor die 12 in intermediate packaging structure 28. Illustrated in drawing FIG. 3 (vias not shown) is an intermediate packaging structure 28 containing two semiconductor [die] dice 12, wherein the interposer 10 surrounds at least two sides of each semiconductor die. Since the bond pads 26 of each semiconductor die must be in contact with vias 24, multiple semiconductor die 12 must be positioned in groups of two in a back-to-back configuration so that all semiconductor die 12 are in electrical communication with substrate 22. Intermediate packaging structure 28 is then attached to the substrate 22 through the electrical contacts 20 on the first surface 16 of the interposer. The substrate 22 may be any type of semiconductor substrate known in the art, such as a printed circuit board. The semiconductor die 12 and substrate 22 are in electrical communication through the bond pads 26 and the electrical contacts 20, which are in contact with the vias 24. The vias 24 may be filled with a conductive material to provide electrical communication between the semiconductor die 12 and substrate 22.

[0033] The high density semiconductor die package 14 accommodates more than two semiconductor die by weaving the flexible interposer 10 around groups of two semiconductor dice. Since the bond pads 26 of each die must be in contact with vias 24, the two semiconductor dice 12 must be positioned in a back-to-back configuration so that all semiconductor [die] dice 12 are in electrical communication with substrate 22. As is illustrated in drawing FIG. 5 (bond pads and vias not shown), the interposer weaves in a serpentine fashion between groups of two semiconductor dice.

[0034] As is illustrated in drawing FIG. 5 (bond pads, vias, and substrate not shown), the present invention also relates to a method of packaging semiconductor [die] dice in a high density arrangement. The semiconductor [die] dice are packaged by providing at least one semiconductor die 12, a flexible interposer 10, and a substrate 22. The interposer 10 is folded

around and attached to the semiconductor [die] dice 12. The interposer 10 has a first surface 16, a second surface 18, and vias 24 that extend through the interposer 10 from the first surface 16 to the second surface 18. The first surface 16 includes electrical contacts 20. The semiconductor [die] dice 12 are attached to the interposer 10 through bond pads 26 on the active surface of the semiconductor die 12 to form intermediate packaging structure 28. Intermediate packaging structure 28 is then attached to substrate 22 through the electrical contacts 20 to form a high density semiconductor package 14. This attachment also results in electrical communication between the semiconductor die 12 and the substrate 22. In a high density semiconductor package 14 containing one semiconductor die 12, the interposer 10 is folded around the semiconductor die 12 so that at least three sides of the semiconductor die are surrounded, as is illustrated in drawing FIG. 2 (vias and substrate not shown). In a high density semiconductor package 14 containing two semiconductor [die] dice 12, the interposer 10 surrounds at least two sides of each semiconductor die 12, as is illustrated in drawing FIG. 3 (vias and substrate not shown). Illustrated in drawing FIG. 5 (bond pads, vias, and substrate not shown) is that the interposer 10 weaves in a serpentine fashion between semiconductor die 12 stacked in groups of two when a high density semiconductor package 14 containing more than two semiconductor dice 12 is desired. Additionally, electrical contacts 20 may be applied to a top surface 30 of the package 14, as is shown in drawing FIG. 6 (bond pads, vias, and substrate not shown), so that the package 14 can be attached to other semiconductor devices, depending on the desired application.

IN THE CLAIMS

A marked-up version of each of the presently amended claims highlighting the changes thereto, follows:

7. (Amended) A high density semiconductor package having at least two semiconductor die comprising:
a substrate having at least one contact pad on a surface thereof; and
a flexible interposer folded around a first semiconductor die of said at least two semiconductor die, said interposer including a first surface having a plurality of electrical contacts for electrically connecting the first semiconductor die to a substrate, a second surface, and a plurality of vias extending through said interposer from said first surface to said second surface, the first semiconductor die having a plurality of bond pads on a surface thereof and a back surface, the first semiconductor die positioned in a back-to-back configuration with another semiconductor die of said at least two semiconductor die and attached to said interposer to form an intermediate packaging structure; at least one contact of said plurality of contacts of said flexible interposer connected to the at least one contact pad of said substrate.

10. (Amended) The [interposer] package of claim 7, wherein said second surface surrounds at least two sides of the first semiconductor die around which said interposer is folded.

19. (Amended) The [interposer] method of claim 16, wherein said second surface of said interposer surrounds at least two sides of the at least one semiconductor die around which said interposer is folded.

24. (Amended) The method of claim 23, wherein said attaching said at least one die further comprises:

attaching multiple semiconductor die in groups of two semiconductor die, said semiconductor die having a [in a] back-to-back configuration, [the] a back side of one semiconductor die substantially contacting [the] a back side of another semiconductor die of a group.

27. (Amended) A computer system comprising:
an input device;
an output device;
a processor, coupled to said input device and said output device; and
a memory module, coupled to said processor, comprising:
a module board having at least one electrical circuit in electrical
communication with at least one high density semiconductor package; and
said high density semiconductor package attached to and in electrical
communication with said module board, said package comprising:
a flexible interposer folded around at least one semiconductor die,
said interposer including a first surface having a plurality of electrical
contacts for electrically connecting said at least one semiconductor die to a
substrate, a second surface, and a plurality of vias extending through said
interposer from said first surface to said second surface, said at least one
semiconductor die having a plurality of bond pads on a surface thereof and
a back side surface, said at least one semiconductor die attached to said
interposer to form an intermediate packaging structure; and
said substrate attached to said intermediate packaging structure,
said substrate connected to said die through said electrical contacts and
said plurality of bond pads.

30. (Amended) The computer system of claim 27, wherein said computer system further comprises a personal digital assistant.